Paleontological Research, vol. 3, no. 1, pp.49-56, 3 Figs., April 30, 1999

Occurrence of Carboniferous corals from the Geumcheon Formation of Danyang area, Korea

JEONG-YUL KIM[1], HYO-NYONG LEE[1] and CHANG-HI CHEONG[2]

[1]*Department of Earth Science Education, Korea National University of Education, Cheongwon, Chungbuk 363-791, Korea*
[2]*Department of Geological Sciences, Seoul National University, Seoul 151-749, Korea*

Received 2 October 1998; Revised manuscript accepted 5 February 1999

Abstract. Two species of Carboniferous coral, *Arachnastraea manchurica* and *Diphyphyllum delicatum*, are described for the first time from the upper part of the Geumcheon Formation of the Danyang area, Korea. They were previously reported as Devonian corals, *Disphyllum* sp. and *Phillipsastraea* sp. Associated fossils are fusulinids, including *Beedeina schellwieni, B. siviniensis, B. samarica, B.* sp., *Fusulina cylindrica, F.* sp., *Fusulinella mosquensis, Fusulinella provecta, Neostaffella sphaeroidea*, and *Ozawainella turgida*. Occurrence of these corals and fusulinids suggests that the upper part of the Geumcheon Formation is middle Moscovian in age.

Key words: Carboniferous, coral, Danyang area, Korea

Introduction

Yabe and Suzuki (1955) first reported specimens of corals from a limestone bed in Danyang area, Korea. They assigned them in open nomenclature to colonial corals of Devonian type as *Disphyllum* sp. and *Phillipsastraea* sp. and suggested that Devonian deposits existed in Danyang area. Unfortunately, their specimens were lost. Furthermore, they figured only one weathered surface and one polished-slab figure of *Disphyllum* sp. and offered no systematic descriptions.

On the basis of a second discovery of coral specimens of *Phacellophyllum* sp.? (*Disphyllum* sp.) associated with fusulinids including *Fusulina* sp., *Fusulinella* sp., and *Neostaffella* sp. from nearly the same horizon as that of Yabe and Suzuki (1955), Cheong (1972) saw a problem in the Danyang area, with a Devonian dating. He mentioned that the limestone containing the coral is not Devonian but Moscovian (Late Carboniferous) in age and surmised that this coral, which had been known as a Devonian type, probably survived into the Carboniferous.

Several months after Cheong's report, Kato (1972) reexamined the figures of Yabe and Suzuki (1955) and briefly documented that *Disphyllum* sp. and *Phillipsastraea* sp. reported from the Danyang area by Yabe and Suzuki (1955) are *Diphyphyllum* sp. and *Arachnastraea* sp. respectively.

Recently well preserved coral specimens, which are closely associated with abundant fusulinids, were discovered from a limestone bed of the Geumcheon Formation by the present authors. The purpose of this paper is to report an additional occurrence of Carboniferous coral specimens, which are described here as *Diphyphyllum delicatum* and *Arachnastraea manchurica*, and to compare these with the Devonian corals *Disphyllum* sp. and *Phillipsastraea* sp. illustrated by Yabe and Suzuki (1955).

Geologic setting and fossil locality

General geological studies in the Danyang area have previously been carried out by many investigators (Kobatake, 1942; Brill, 1957; Lee and Kim, 1966; Son *et al.*, 1967; Park and Cheong, 1975; Park *et al.*, 1975; Kim, 1981). Kim (1971) studied the Paleozoic and Mesozoic paleocurrents of the Danyang Coalfield on the basis of sedimentary structures. Structural analysis and tectonic studies of the Danyang area have been recently carried out by Cho *et al.* (1986), Kim and Koh (1992), Kim *et al.* (1992a), Kim *et al.* (1992b), and Kim *et al.* (1994).

The Permo-Carboniferous sedimentary strata, the Pyeongan Supergroup, in southern Korea are widely distributed in the Danyang, Taebaeg, Yeongweol, Jeongseon, and Gangneung areas. The sediments are shallow marine to fluvial in origin and consist predominantly of sandstone and shale with small amounts of carbonate.

Cheong (1973) subdivided the Pyeongan Supergroup into the Carboniferous Manhang and Geumcheon formations, the Permian Bamchi, Jangseong, Hambaegsan, Dosagok and Kohan formations, and Triassic Donggo Formation in ascending order.

In Danyang area, the Carboniferous strata disconformably cover the Ordovician strata and are divided into two formations, namely, the Manhang and Geumcheon formations (Cheong, 1971) and are inturn unconformably overlain by the Jurassic deposits (Figure 1). Cheong (1971) firstly carried out

biostratigraphic research on fusulinids in the Danyang area and described 37 fusulinid species belonging to 11 genera.

The Carboniferous Manhang Formation unconformably overlies the Ordovician strata. The formation, about 175 m thick, is characterized by red to purple shale and greenish coarse sandstone, with the intercalation of nine white and

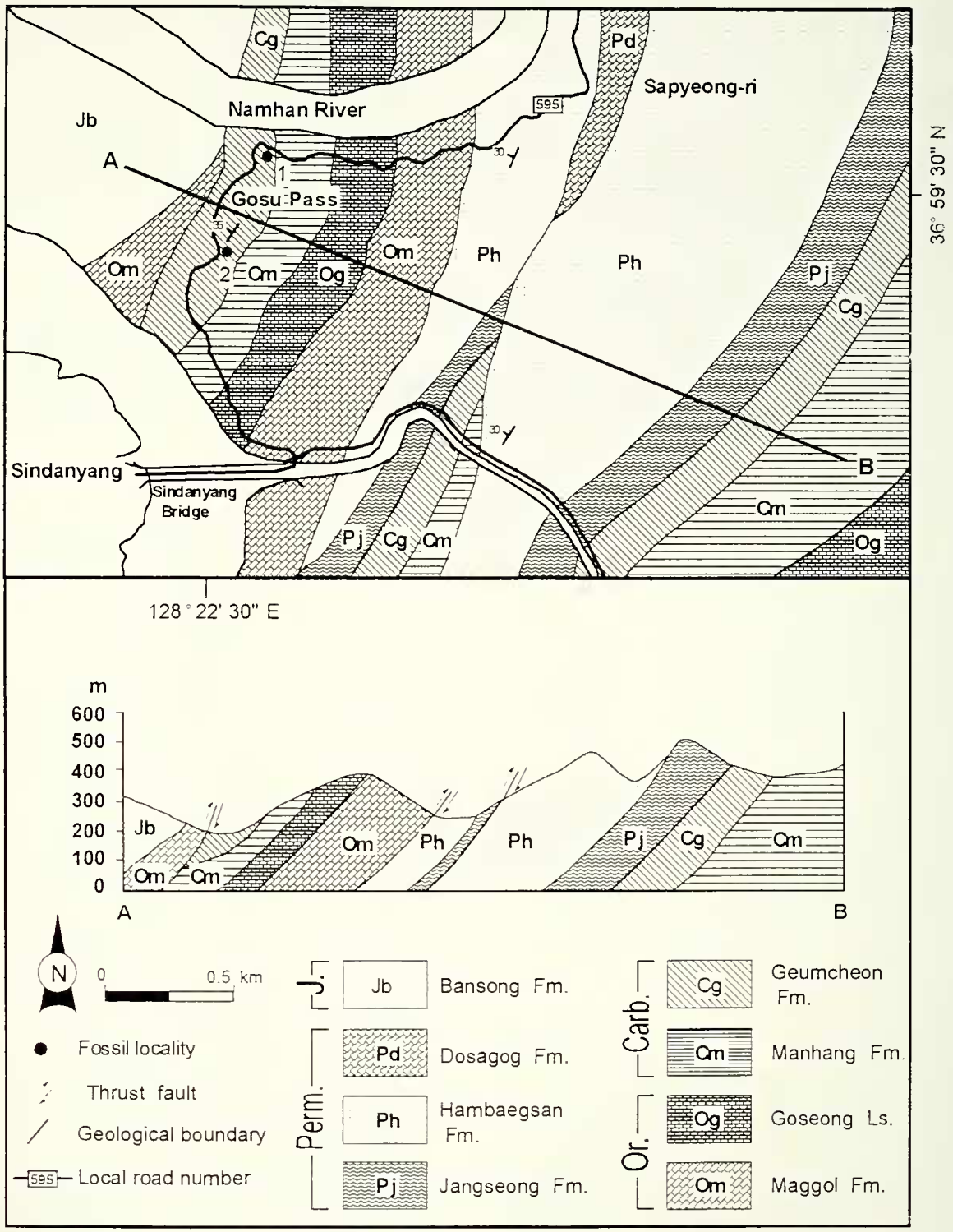


Figure 1. Geological map and fossil localities of study area. (After Son *et al.*, 1967 ; Lee and Kim, 1995)

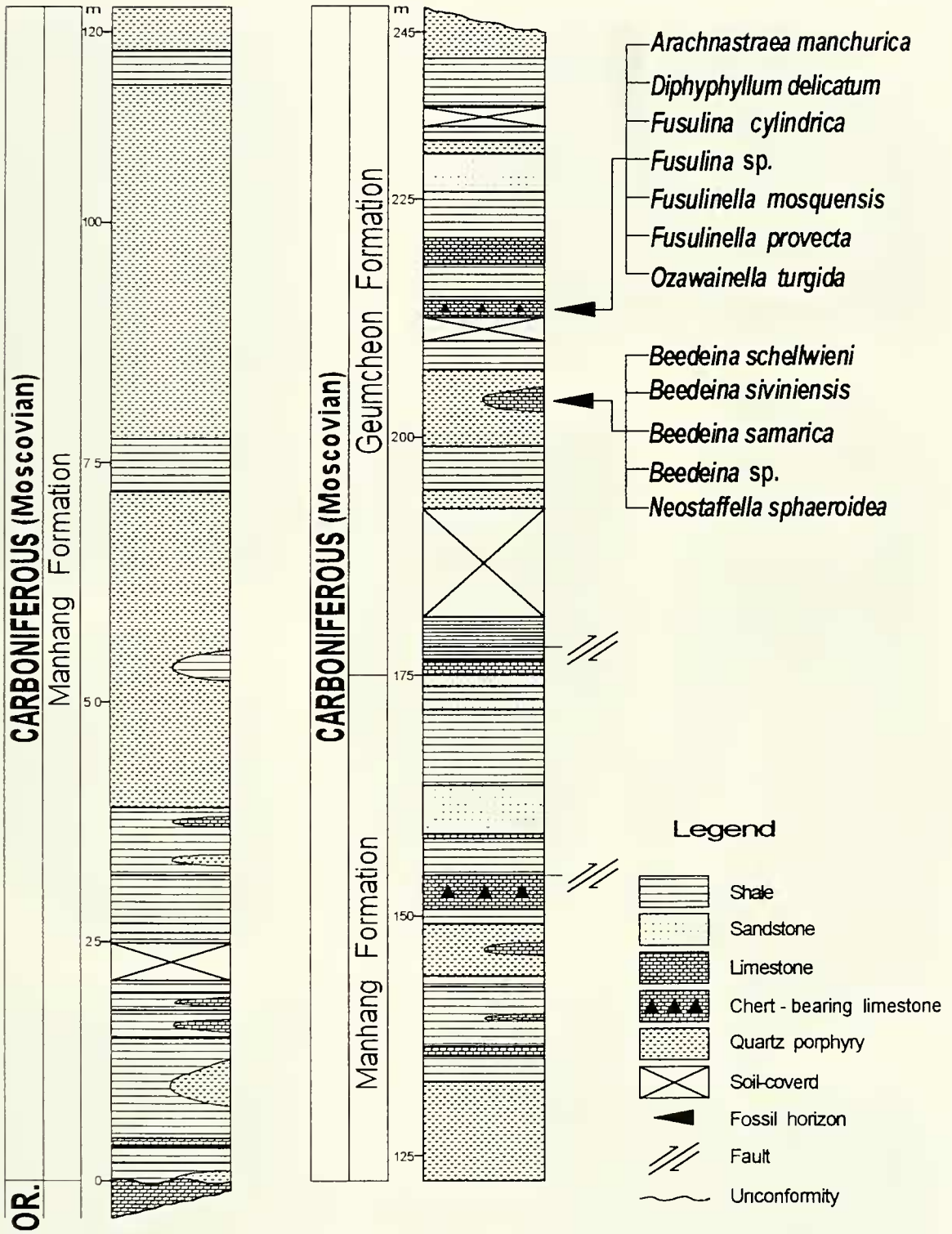
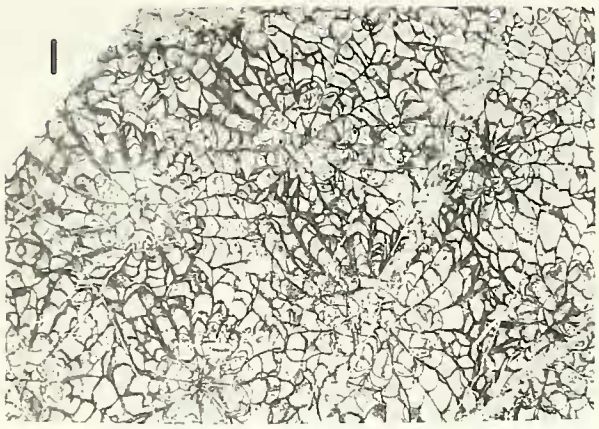
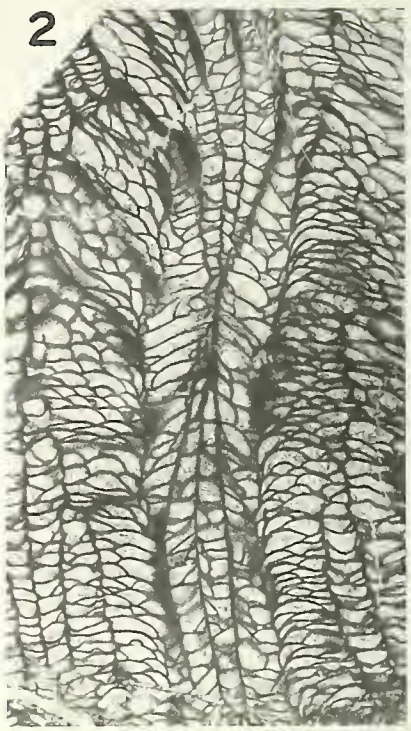


Figure 2. Measured stratigraphic section of study area.

light gray limestone beds or lenses in the measured section (Figure 2). In the upper part, the formation contains gray to bluish-gray limestone which bears white chert.

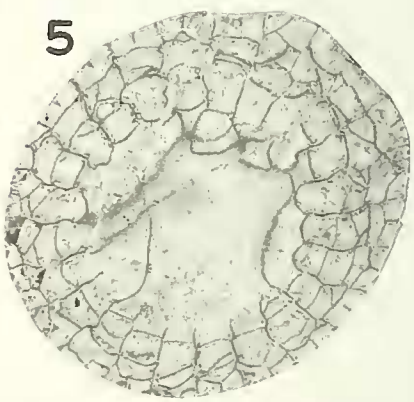
The Geumcheon Formation from which the coral specimens were collected is about 70 m thick and comformably covers the Manhang Formation. The formation comprises a

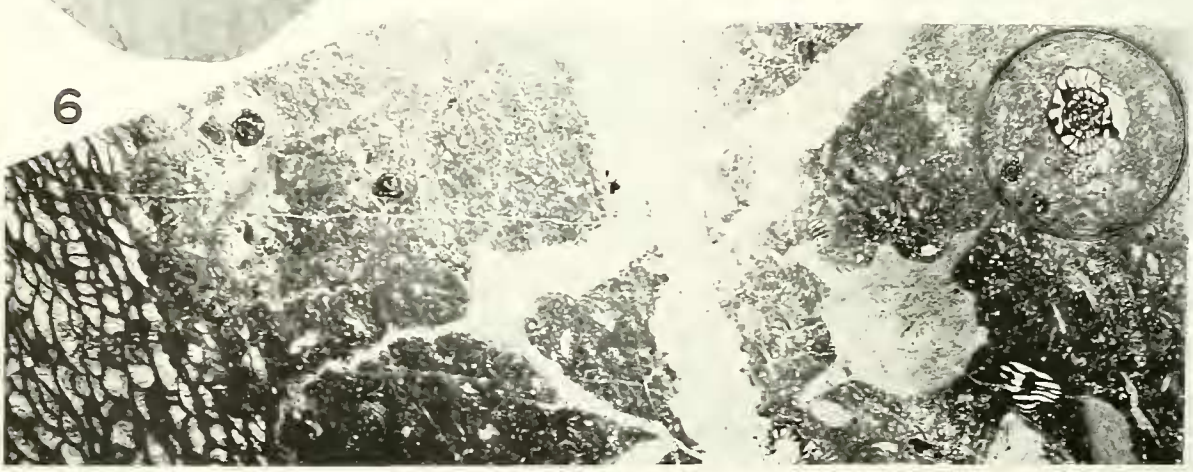

1


2


3


4


5


6

variety of terrigenous sediments intercalated with dark gray limestone lenses (Figure 2). The upper part of the formation is characterized by black shale and greenish sandstone. Abundant and diverse corals and fusulinids were only recorded from the limestone units in the formation. Lee and Kim (1995) also described *Beedeina schellwieni*, *Fusulina* sp., *Neostaffella sphaeroidea*, and *Ozawainella turgida* from the Geumcheon Formation near Gosu Pass in the Danyang area.

All of the specimens considered here were collected from a measured section of the Geumcheon Formation exposed in Gosu Pass along the local road 595, Danyang area (Figure 1). The fossil locality 1 is exposed near the top of Gosu Pass, about 1.2 km north of the Sindanyang Bridge. The limestone bed of locality 1, which is 2 m in thickness, is composed of abundant fusulinids and coral fragments which can not be used in the description. Many kinds of bioclasts, foraminifera, conodonts, brachiopods, and crinoids, were also found from the limestone bed.

The fossil locality 2 is about 800 m northwest from the Sindanyang Bridge. Fossil specimens were collected from a 5 m thick chert-bearing limestone bed which is stratigraphically nearly 40 m above the base of the Geumcheon Formation. The limestone is characterized by gray to dark gray color (Figure 2). Abundant corals together with fusulinids, brachiopods, bryozoa, and crinoid stems are cleary shown on the weathered surface of limestone bed.

Systematic description

The conventional treatment has been followed in the taxonomic hierarchy above the species level. The morphologic terminology used for systematic description followed is that of Hill (1935, 1956, 1981), the terminology of microstructural elements is that of Kato (1963, 1968). Specimens collected for the present study and described herein are housed in the Department of Earth Science Education, Korea National University of Education.

Phylum Cnidaria Hatschek, 1888
Class Anthozoa Ehrenberg, 1834
Order Rugosa Milne-Edwards and Haime, 1850
Suborder Streptelasmatina Wedekind, 1927
Family Lithostrotionidae d'Orbigny, 1851
Genus ***Arachnastraea*** Yabe and Hayasaka, 1916

Arachnastraea Yabe and Hayasaka, 1916, p. 69.

Type species.—*Arachnastraea manchurica* Yabe and Hayasaka, 1916, from the Lower Permian of South Manchuria.

Diagnosis.—Corallum compound, massive, typically cerioid or astraeoid. Septa numerous, of two orders. Septa thin, usually extending across tabularium to columella but partly discontinuous in dissepimentarium. Both major and minor septa are well developed. Tabulae conical, complete or incomplete, regular dissepimentarium (slightly modified after Hill, 1956).

Remarks.—In the typical species of the Devonian *Phillipsastraea* d'Orbigny, the septa never extend to the center of the corallites with horse-shoe dissepiments. The septa are dilated, especially at inner margin of dissepimentarium, and there is always a conspicuous inner wall formed by the abrupt thickening of all the septa. These characteristic features are not visible in *Arachnastraea* (Yabe and Hayasaka, 1916). Kato (1972) concluded that Yabe and Sugiyama (1940) misdescribed *Arachnastraea* as *Phillipsastraea* in an occurrence from Cheonseongri, Suncheongun, Pyeongannamdo, Northwest Korea.

Arachnastraea manchurica Yabe and Hayasaka, 1916

Figures 3-1; 3-2

Arachnastraea manchurica Yabe and Hayasaka, 1916, p. 69.

Material.—KNUE 96201-96216 (KNUEDY Locality 2). Four specimens for this study were collected by the present authors from the measured stratigraphic section (see Figure 2).

Description.—*Transverse section description:* Corallum is astraeoid and composed of nearly equal-sized polygonal corallites which are 4.1-6.6 mm in diameter and have 9-11 major septa. Septa are thin, straight, alternately long and short, and fibronormal in terms of microstructure. Major septa reach the center of the corallite. Corallite walls are almost indistinguishable from septa and dissepiments. In most corallites, the major septa are 2.0-3.5 mm long and minor septa are 0.8-2.4 mm long. Minor septa typically extend about 2/3 length of major septa to tabularium wall. Dissepimentarium is formed by 3-5 rows and is 0.3-2.7 mm. Tabularium has a diameter of on average 2.3 mm.

Longitudinal section description: Dissepiments are well developed in the peripheral part, elongate in form and not much inclined. Dissepimentarium rather wide, occupying about 2/3 of the diameter of the corallites and consisting of 3-5 rows of dissepiments which are an average of 2 mm long. Axial tabellae and periaxial tabellae are similarly inclined. Diameter of the tabularium varies around the average of 2.2 mm, from 1.8 to 3.0 mm. In the tabularium, the tabulae adjacent to the dissepimentarium have a slope of 25°-40°.

Remarks.—One of the so-called 'Devonian type corals' from Cheonseongri described by Yabe and Sugiyama (1940) was reidentified by Kato (1972) as *Arachnastraea kaipingensis* (Grabau). It was the first record of occurrence of *Arachnastraea* in Korea. *Arachnastraea manchurica* differs from *Arachnastraea kaipingensis* in corallite walls, columella and

Figure 3. **1, 2.** *Arachnastraea manchurica* Yabe and Hayasaka; 1, transverse section (×7, KNUE 96201), 2, Longitudinal section (×7.5, KNUE 96215). **3-5.** *Diphyphyllum delicatum* Minato and Kato; 3, transverse section showing both the early and mature stages (×8, KNUE 96219), 4, slightly obliquely cut logitudinal section (×7, KNUE 96229), 5, slightly obliquely cut transverse section (×7, KNUE 96217). **6.** association of *Arachnastraea manchurica* and *Fusulinella* sp. (×10, KNUE 96199).

dissepimentarium. In the latter the corallum is cerioid-astraeoid and corallite walls are well developed, sharply zigzag and partially depressed. The dissepimentarium of the latter consists of 3-4 rows of regular dissepiments.

Family Lithostrotionidae d'Orbigny, 1851
Subfamily Diphyphyllininae Dybowski, 1873
Genus ***Diphyphyllum*** Lonsdale, 1845

Diphyphyllum Lonsdale, Hill, 1956, p. 283; Hill, 1981, p. 383.

Type species.—*Diphyphyllum concinnum* Lonsdale, 1845.

Diagnosis.—Fasiculate corallum, typically without columella. Septa short, continuous in dissepimentarium and amplexoid in tabularium. Columella absent or impersistent. Tabulae convex or flat, with downturned edges. Dissepimentarium narrow, composed of one or more rows of small dissepiments (slightly modified after Hill, 1956).

Remarks.—The species of *Diphyphyllum* may have a wide range of variability in terms of the structure, shape and mode of the tabulae. This genus has inner tabulae which are strongly arched, and each arch rests upon the arch below. In addition, Sando and Bamber (1985) mentioned that this genus is very similar to *Siphonodendron,* from which it differs by having flat or convex tabulae and by lacking a columella or having a thin, vertically discontinuous one.

Armstrong (1970) regarded a smaller group of species, such as *Diphyphyllum venosum*, *Diphyphyllum nasorakensis* and *Diphyphyllum klawockensis*, as having complete tabulae with broad flat tops and downturned edges that extend to the dissepimentarium without touching the lower tabulae.

The majority of the descibed species of *Diphyphyllum* indicated a late Early Carboniferous age (Minato and Kato, 1975). This genus is common in North America and is found exclusively in the shallow-water carbonate lithofacies (Sando and Bamber, 1985).

Diphyphyllum delicatum Minato and Kato, 1957

Figures 3-3—3-5

Diphyphyllum delicatum Minato and Kato, 1957, p. 137, text-figs. A-C; Minato and Kato, 1974, p. 56-60.

Material.—KNUE 96217-96245 (KNUEDY Locality 2). Only two specimens for this study were collected by the present authors from the measured stratigraphic section (see Figure 2).

Description.—Transverse section description: Corallum is compound, fasciculate and dendritic rather than phaceloid. Corallites are circular to subcircular. Corallites are closely adjacent, and are often in contact. Mature corallites range from about 6.7 to 11.4 mm in diameter and possess 18 to 25 major septa. Both major and minor septa are thin, fibronormal in terms of microstructure. Major septa are 1.5-2.2 mm in length, protruding 0.2-0.9 mm in tabularium, except for some major septa which are 0.9-1.1 mm in length. Minor septa are usually confined to adaxial first row of dissepiments, rarely protruding into second row of dissepiments, and are 0.25 to 0.38 mm in length. Dissepimentarium ranges from 1.1 to 2.2 mm in width and consists of one to three rows of regular dissepiments. Tabularium varies from 4.1 to 6.4 mm in width and is open without any axial structure.

Longitudinal section description: Corallites are cylindrical and rather closely disposed. Dissepimentarium is 0.5 to 1.9 mm wide and consists of one to three rows of inclined, inflated to globose dissepiments. Tabulae are mostly complete, slightly concave in central part of the corallite, 4 to 9 in a vertical distance of 5 mm. However, they turn downward at an average angle of 32° before joining the dissepiments.

Remarks.—Our specimens differ slightly from Minato and Kato's (1975, pl. 9, figs. 2-6, pl. 10, figs. 1-4) species *Diphyphyllum delicatum*, which was described from the Upper Carboniferous Nagaiwa Series of northeast Japan, by having more numerous major septa, a wider dissepimentarium, and a more strongly developed row of dissepiments. Igo and Kobayashi (1980) described a new subspecies, *Diphyphyllum delicatum nishitamensis*, from the Itsukaichi District, Tokyo, Japan, which is similar to, but not conspecific with *Diphyphyllum delicatum* illustrated by Minato and Kato (1975). Igo and Kobayashi (1980) noted that *Diphyphyllum delicatum* and *Diphyphyllum delicatum nishitamensis* differ noticeably in the length of major and minor septa. The former is characterized by short major and minor septa, while the subspecies has longer septa compared with the size of the corallite.

As Minato and Kato (1957) mentioned, *Diphyphyllum* has a long stratigraphic range from the Lower Carboniferous to Permian, but this particular species is confined to the upper part of the Upper Carboniferous Geumcheon Formation in the Danyang area.

Discussion

One of the purposes of this study is to reexamine the Devonian corals mentioned by Yabe and Suzuki (1955). According to Kato (1972), Suzuki earlier collected several coral specimens in Gosuri, Danyang in 1944, but these materials are lost. Yabe and Suzuki (1955) reported the occurrence of the Devonian corals *Disphyllum* sp. and *Phillipsastraea* sp. Their figures 1 and 2 are index maps of the fossil locality, while figures 3 and 4 show the corals on the weathered surface of the limestone near Gosu Pass in Danyang area. The figures are not clear, but colony type and internal structure of corals were, however, distinguished.

On the basis of their figure 3, several clues to identification of the corals were found by the present authors. First of all, the corallites in figure 3 are compound, fasciculate and dendritic rather than phaceloid. Although Yabe and Suzuki (1955) identified them as *Disphyllum* sp., the branches of their coral specimens are too irregular to be those of *Disphyllum*. The second is that the septa are very short and the dissepimentarium are very narrow with one or two rows of small dissepiments. In longitudinal view, the tabulae are convex with downturned edges without columella. These are typical characters of *Diphyphyllum*. It is considered that the coral specimens described by Yabe and Suzuki (1955) are not of the Devonian genus *Disphyllum*, but the Carboniferous *Diphyphyllum*. *Disphyllum* sp. is illustrated only in figure 3 of

Yabe and Suzuki (1955), but they did not provide any illustrations of *Phillipsastraea* sp.

Furthermore, fusulinids and conodonts occur abundantly from the Geumcheon Formation. A number of fusulinids are observed together with corals in the same thin sections (Figure 3-6). Because the Carboniferous corals have long ranges, both fusulinids and conodonts may provide a useful criteria for understanding the paleoecology and determining the geologic age of the Geumcheon Formation.

Conclusion

Two species of rugose corals from the Geumcheon Formation in the Danyang area, Korea are described as *Arachnastraea manchurica* and *Diphyphyllum delicatum*. The corals indicate that the age of the Geumcheon Formation is middle Moscovian, Late Carboniferous.

Coral specimens from the Danyang area once illustrated as the Devonian corals *Disphyllum* sp. and *Phillipsastraea* sp. (Yabe and Suzuki, 1955), are considered Carboniferous corals, *Diphyphyllum* sp. and *Arachnastraea* sp. respectively.

Acknowledgments

We wish to sincerely thank Makoto Kato, Professor Emeritus of Hokkaido University, and Hisayoshi Igo, Professor Emeritus of the University of Tsukuba for sending useful references and giving comments. We wish to express our thanks to E.W. Bamber, Geological Survey of Canada, Lin Baoyu, Institute of Geology, Chinese Academy of Geological Sciences, Lin Ying Dang, Changchum College of Geology, and Wang Xun Lian, China University of Geosciences, for kindly offering helpful comments and sending many copies of valuable references. Special thanks are given to two anonymous referees for critically reviewing the original manuscript and suggesting numerous useful comments and constructive revisions.

References

Armstrong, A.K., 1970: Mississippian rugose corals, Peratovich Formation, west coast, Prince of Wales Island, southeastern Alaska. *U.S. Geological Survey Professional Paper*, no. 534, 44 p.

Brill, G., 1957: Geology of Tanyang Coalfield of the Republic of Korea. *Geological Report on Coalfields of Korea*, vol. 1, p. 75-98.

Cheong, C.H., 1971: Stratigraphy and paleontology of the Danyang Coalfield, North Chungcheong-do, Korea. *Journal of Geological Society of Korea*, vol. 7, p. 63-88.

Cheong, C.H., 1972: On the Devonian problem in Korea. *Journal of Geological Society of Korea*, vol.8, p. 53-54.

Cheong, C.H., 1973: A paleontological study of the fusulinids from the Samcheog Coalfield, Korea. *Journal of Geological Society of Korea*, vol. 9, p. 47-82.

Cho, M.J., Choi, Y.S., Kang, P.C. and Choi, K.H., 1986: A study on structural analysis for the southern part of Taebaegsan region. *Researches on Coal Resources* vol. 5 (KR-86-2-10), p. 239-279.

Hill, D., 1935: British terminology for rugose corals. *Geological Magazine*, vol. 72, p. 481-519.

Hill, D., 1956: Rugosa. *In*, Moore, R.C. *ed.*, *Treatise on Invertebrate Paleontology, Part F, Coelenterata*, p. 233-324. Geological Society of America and University of Kansas Press, Lawrence.

Hill, D., 1981: Rugosa and Tabulata. *In*, Teichert, C. *ed.*, *Treatise on Invertebrate Paleontology, Part F, Coelenterata, Supplement 1*, 762 p. Geological Society of America and University of Kansas Press, Lawrence.

Igo, H. and Kobayashi F., 1980: Carboniferous corals from the Itsukaichi district, Tokyo, Japan. *Science Report, Institute of Geoscience, University of Tsukuba, Section B,* vol. 1, p. 149-162.

Kato, M., 1963: Fine skeletal structures in Rugosa. *Journal of Faculty of Science, Hokkaido University, Series 4*, vol. 11, p. 571-630.

Kato, M., 1968: Note on the fine skeletal structures in Scleractinia and Tabulata. *Journal of the Faculty of Science, Hokkaido University, Series 4,* vol. 14, p. 45-50.

Kato, M., 1972: Devonian of Korea. *Journal of Geological Society of Japan,* vol. 78, p. 541-544.

Kim, H.M., 1971: Paleozoic and Mesozoic paleocurrents of the Danyang Coalfield, Korea. *Journal of Geological Society of Korea*, vol. 7, p. 257-276.

Kim, J.H. and Koh, H.J., 1992: Structural analysis of the Danyang area, Danyang Coalfield, Korea. *Journal of Korean Institute of Mining Geology*, vol. 25, p. 61-73.

Kim, J.H., Lee, J.Y. and Nam, K.H., 1992a: Geological structures of the Yeongchun area, Danyang Coalfield, Korea. *Journal of Korean Institute of Mining Geology,* vol. 25, p. 179-190.

Kim, J.H., Lee, J.Y., Nam, K.H. and Choi, B.Y., 1992b: Paleostress analysis within the thrust zone, Yeongchun, Danyang Coalfield, Korea. *Journal of Geological Society of Korea*, vol. 28, p. 184-195.

Kim, J.H., Lee, J.Y. and Nam, K.H., 1994: Pre-Jurassic thrust movement in Danyang area, Danyang Coalfield, Korea. *Journal of Geological Society of Korea*, vol. 30, p. 35-40.

Kim, J.S., 1981: Geology of the Danyang Coalfield. *Journal of Geological Society of Korea*, vol. 17, p. 131-133.

Kobatake, N., 1942: Geology of the Tanyo Coalfield and its environment in N. Chuseido. *Science Report, Geological Institute of Kyoto University*, vol. 1, p. 1-20.

Lee, C.Z. and Kim, G.R., 1995: Fusulinids from the Geumcheon Formation in Danyang Coalfield, Korea. *Journal of Korean Earth Science Society*, vol. 16, p. 144-151.

Lee, D.W. and Kim, D.S., 1966: Geology of northern part of Danyang Coalfield. *Geological Report on Coalfield of Korea*, vol. 7, p. 5-32.

Minato, M., 1975: Upper Carboniferous corals from the Nagaiwa Series, southern Kitakami Mountains, N.E. Japan. *Journal of Faculty of Science, Hokkaido University*, vol. 16, p. 43-119.

Minato, M. and Kato, M., 1957: Two Carboniferous corals from the Kitakami Mountains, northeast Honshu, Japan. *Transactions and Proceedings of the Palaeontological Society of Japan, New Series*, no. 28, p. 137-142.

Park, S.I. and Cheong, C.H., 1975: A study on the Jurassic Sapyeongri Conglomerate in the vicinity of Danyang, N. Chungcheongdo, Korea. *Journal of Geological Society of Korea*, vol. 11, p. 24-37.

Park, J.S., Shin, M.S., Chung, C.S., Lee, M.H., Yoon, Y.D.,

Kim, S.H. and Hwang, H.S., 1975 : *Geological investigation report of Danyang Coalfield*. p. 54.

Sando, W.J. and Bamber, E.W., 1985 : Coral zonation of the Mississippian System in the western interior province of North America. *U.S. Geological Survey Professional Paper*, no. 1334, 55 p.

Son, C.M., Cheong, C.H., Kim, B.K., Lee, S.M. and Kim, S.J., 1967 : Geology of the Danyang Coalfield. *Geological Report on Coalfields of Korea*, vol. 8, p. 73-94.

Yabe, H. and Hayasaka, I., 1916 : Paleozoic corals from Japan, Korea and China. *Journal of Geological Society of Tokyo*, vol. 23, p. 9-22.

Yabe, H. and Sugiyama, T., 1940 : Discovery of corals of Devonian types from Tyosen (Korea). *Proceedings of the Japan Academy*, vol. 15, p. 305-310.

Yabe, H. and Suzuki, A., 1955 : Second occurrence of colonial coral of Devonian type in Tyosen (Korea). *Proceedings of the Japan Academy*, vol. 31, p. 355-359.

Cheonseongri 天聖里, Danyang 丹陽, Donggo Formation 東古層, Dosagok Formation 道士谷層, Gangneung 江陵, Geumcheon Formation 黔川層, Gosu 古藪, Hambaegsan Formation 咸白山層, Jangseong Formation 長省層, Jeongseon 旌善, Kohan Formation 古汗層, Manhang Formation 晩項層, Pyeongan Supergroup 平安累層群, Sindanyang 新丹陽, Taebaeg 太白, Yeongweol 寧越
